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SAN JOAQUIN VALLEY AND SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA. A PRELIMINARY EVALUATION OF STREAM FLOW REQUIREMENTS FOR WATER QUALITY CONTROL

Public Health Service
San Francisco, California

June 1963

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CALIFORNIA

A Preliminary Evaluation of Stream Flow Requirements for Water Quality Control

SUMMARY REPORT

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DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service, Region IX
San Francisco, California

JUNE, 1963

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CALIFORNIA

A Preliminary Evaluation of Stream Flow Requirements for Water Quality Control

SUMMARY REPORT

Prepared at the Request of

DEPARTMENT OF THE INTERIOR
Bureau of Reclamation, Region 2
Sacramento, California

by

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service, Region IX
San Francisco, California

JUNE, 1963

I

PREFACE

This report contains a summary of findings, conclusions and recommendations which were developed from a preliminary evaluation of stream flow requirements for water quality control in the San Joaquin Valley and Sacramento - San Joaquin Delta of California. Also considered in the scope of the report were the problems of disposal of agricultural drainage from the Federal - State San Luis Project.

The presentation of supporting data, analysis of data, documentation, references and additional diagrams are compiled in a separate Appendix Report.

It is hoped that this report may serve to focus attention on the need for a detailed comprehensive investigation of the regional water pollution control and water quality problem.

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INTRODUCTION

PURPOSE

The purpose of this report is to provide the United States Bureau of Reclamation, Region 2, Sacramento, with preliminary information on the need for and value of storage in federal reservoirs for the purpose of regulating stream flow for water quality control in selected rivers and the Delta region of the San Joaquin and Sacramento River Basins and to provide information and Public Health Service views regarding the disposal of agricultural drainage from the Federal - State San Luis Project. Specific objectives are:

1. To evaluate water quality characteristics at key locations within the study area and to project future quality under various project plans and future land and water uses.

2. To evaluate sources of water pollution under existing and proposed stages of development.

3. To determine the flow requirements necessary to meet desirable water quality objectives.

4. To estimate the value of providing storage for water quality control purposes.

5. To evaluate proposed disposal sites for agricultural drainage from the San Luis Project service area.

The time horizon selected for projection purposes is the year 2020 by twenty year increments beginning with 1960.

SCOPE

In this study, consideration has been given only to existing information, data and reports on water requirements, water quality and pollution control problems in the study areas. This approach was

necessary because of limited time and funds and the large volume of pertinent information already available regarding the study areas.

The specific areas of investigation are as follows:

1. San Joaquin River and its major tributaries, the Merced, Tuolumne and Stanislaus Rivers.
2. Cosumnes River
3. American River
4. Sacramento - San Joaquin River Delta
5. San Luis Project

These areas represent those specifically requested by the U.S. Bureau of Reclamation for immediate investigation. The river study areas are restricted to the reaches below the Bureau of Reclamation's proposed East Side Canal.

REQUEST AND AUTHORITY

Correspondence requesting U.S. Public Health Service participation in the U.S. Bureau of Reclamation's Delta Investigation was initiated by the Bureau June 6, 1962, and read in part

"--we need a preliminary determination of flow conditions as related to the environment in the Delta that your agency believes should be maintained from the standpoint of water quality control. The initial appraisal should include the following items together with an estimate of benefits for changes in the present environment or benefits for maintaining present conditions until the year 2020.

1. Outflow from the Delta
2. Flow distribution in Delta channels
3. Flow schedules in main channels in the American,

Cosumnes, Stanislaus, Tuolumne, Merced, and San Joaquin Rivers."

Subsequent correspondence discussed the proposed study in detail and established a project schedule and tentative completion date of June 30, 1963.

Legislative authorization for Public Health Service participation in projects involving storage for water quality control purposes is contained in Section 2.b of the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Correspondence requesting U.S. Public Health Service participation in the evaluation of the U.S. Bureau of Reclamation's alternative plans for disposal of drainage from the San Luis Unit of the Central Valley Project was initiated by the Bureau June 22, 1962. Actual investigation of the effects of agricultural waste drainage from the San Luis Project was not initiated until February, 1963, due to lack of funds. Correspondence from the Bureau dated January 24, 1963, provided funds to begin this investigation and requested that the Public Health Service "extend the scope of your present Delta investigation to include effects of a San Luis Drain."

ACKNOWLEDGMENTS

Valuable assistance and data for this study were provided by personnel of the following agencies:

United States Department of Interior, Bureau of Reclamation, Region 2, Sacramento, California

United States Department of Interior, Geological Survey, Surface Water Branch and Quality of Water Branch

United States Department of Commerce, Bureau of the Census, and Coast and Geodetic Survey

United States Department of Army, Corps of Engineers, San Francisco District, Bay Model Section

United States Department of Health, Education and Welfare, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio

California Department of Water Resources, San Joaquin Valley Branch, Delta Branch and Bay Area Branch

California Department of Public Health, Bureau of Sanitary Engineering

Central Valley Regional Water Pollution Control Board (No. 5)

California Department of Fish and Game

University of California, Berkeley, Sanitary Engineering Research Laboratory

Contra Costa County Water District

Stanislaus County Planning Commission

Stanislaus County Economic Action Committee

Fresno County Department of Public Works

Fresno County Planning Department

Modesto Irrigation District

The cooperation, data and assistance furnished by the foregoing agencies is sincerely appreciated.

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SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

FINDINGS

General

1. The U.S. Bureau of Reclamation and the California Department of Water Resources are engaged in the planning and construction of major water conservation and trans-basin water transfer facilities within the State of California, the ultimate goal being to provide water short areas south of the Sacramento - San Joaquin Rivers Delta with surplus waters from the north (see Figure 1).

2. The Bureau of Reclamation, Region 2, requested Region IX of the Public Health Service to investigate certain areas particularly significant to its water transfer schemes. The areas selected for this investigation lie in the Central portion of California's Central Valley and include the lower San Joaquin River Basin, (Figure 3), the Cosumnes River Basin, the American River Basin (Figure 13), and the Sacramento - San Joaquin Rivers Delta (Figure 14).

3. This investigation was conducted for the primary purpose of making a preliminary evaluation of flow requirements for quality control purposes from the present to the year 2020 in the specified study areas.

4. With the exception of the western Delta, the economy of the study areas has been predominantly agriculture. The western Delta economy is based primarily on heavy industry, i.e. chemical, petroleum refining, paper products and primary metals.

5. Population in the study areas has increased over 40 per cent in the past decade.

6. Present water use in the Central Valley is estimated to be 11,000,000 acre-feet per year.

7. At present, the only outlet to the ocean for waste waters generated in California's Central Valley (approximately 60,000 square miles) is through the Golden Gate via the Delta, Suisun Bay, Carquinez Straits, San Pablo Bay and North San Francisco Bay.

8. The quality parameter utilized in making determinations of quality control flows was dissolved oxygen. A minimum dissolved oxygen concentration of 5.0 mg/l was used for all reaches of streams, except in salmon spawning areas. For salmon spawning areas, the minimum dissolved oxygen level of 7.0 mg/l was used.

9. Mineral quality has been a problem in localized areas, particularly in the lower San Joaquin River (see Figure 11). However, studies by the California Department of Water Resources indicate that these problems probably will not increase in the future because of planned water conservation and agricultural drainage projects. Areas where mineral quality has been a problem are, in most instances, areas where additional flow is necessary for control of organic wastes. Thus improvement will be realized in both mineral and organic quality with the projected quality control flows.

10. Projections of quality control flows have been based on the assumption that at least secondary treatment of municipal and industrial organic wastes will be provided and that this treatment will remove a minimum of 80, 85, 90, and 95 per cent of the biochemical oxygen demand for the years 1960, 1980, 2000, and 2020, respectively.

11. Because of the economy of the Central Valley is largely

agriculturally oriented, the largest industrial contribution of oxygen demanding wastes is from the food processing industry. For many communities, this source of wastes constitute up to ten times the normal organic loads during the peak of the canning season.

12. Fishing and recreation are becoming increasingly important in all study areas. Of particular impact is the movement of anadromous fishes between the ocean and spawning grounds of the tributary streams.

San Joaquin River Basin

The San Joaquin River Basin study area is shown on Figure 3.

13. Runoff within the San Joaquin Basin is highly controlled. Large irrigated agricultural developments are dependent on a firm regulated water supply.

14. Diversions and direct withdrawals from the streams exhaust the storage releases in summer. Downstream flows are derived from ground water accretions, irrigation returns, and municipal and industrial waste waters. A hydrologic systems chart showing the stream discharges, diversions, and accretions at various gaging stations on the San Joaquin River and major tributaries is shown on Figure 10.

15. The natural surface water quality is excellent but is severely impaired through repeated use as it moves downstream. Beneficial uses affected by this impaired water quality include agriculture, fishing and recreation.

16. Ground water in the San Joaquin basin is generally acceptable. Localized problems include high nitrate concentrations

and increased salinity from upward movement of connate brines. Depressed ground water tables due to over-pumping and excessively high ground waters due to inadequate land drainage also present local problems.

17. Practically all withdrawal uses of surface waters within the basin are for agricultural purposes. Municipal and industrial supplies for cities within the basin are derived almost exclusively from ground water.

18. Surface waters receive significant concentrations of salt from irrigation return flows and a few abandoned gas fields.

19. Organic pollution of surface waters is apparent from several large cities within the basin and has caused fish kills on occasion.

20. The largest industry in this agriculturally oriented basin is food processing. Cannery operations increase organic waste loads during the late summer and early fall.

Cosumnes River Basin

The Cosumnes River Basin study area is shown on Figure 13.

21. Flow in the lower Cosumnes River is intermittent from July through November. Winter rains and spring snow melt maintain a ve consistent flow during the rest of the year.

22. Waters of the Cosumnes River are generally of excellent mine quality.

Pollution problems are not evident in the Cosumnes River basin.

24. Future projected growth within the study area is primarily

residential and commercial and is linked with the industrial growth of the Sacramento metropolitan area.

25. Future waste loadings are patterned after a residential-commercial development.

American River Basin

Tne American River Basin study area is shown on Figure 13.

26. Stream flow in the lower reacnes of the American River is primarily controlled releases from upstream reservoirs. Future minimum flows will be reduced to levels determined for fish life, municipal water supply and pollution control.

27. An operating agreement between the Bureau of Reclamation and the California Department of Fish and Game calls for flow releases for fish protection of 250 cfs from January 1 through September 14 and 500 cfs from September 15 through December 31 with allowance for monthly deficiencies during a critical dry year.

28. The water quality of the American River is excellent.

29. Ground water use has gradually lowered the water table in the Sacramento area.

30. The quality of ground waters is excellent.

31. Present surface water pollution is scattered and not serious.

32. The American River is an important migration route and spawning area for salmon.

The Delta

33. The Sacramento - San Joaquin Rivers Delta is the focal point for the Central Valley's runoff and drainage and is the

interception point of surplus northern waters for transfer south. The Delta study area is shown on Figure 14.

34. The Delta comprises over 50 islands and about 700 miles of interconnecting channels subject to large tidal effects and pronounced variations in seasonal water use and hydrology.

35. The Delta receives high recreation and fishing pressures. This area is particularly important to the striped bass fishery and as a passageway and acclimatization area for anadromous fishes.

36. At the present time, the Bureau of Reclamation exports variable quantities of water (up to about 4200 cfs) from the Delta to the San Joaquin Valley, mainly for irrigation purposes. Surplus water is diverted from the Sacramento River and travels across the Delta through natural channels to a pumping plant on the south edge near Tracy.

37. State and Federal water resources agencies have proposed a number of physical development schemes to transfer additional surplus waters through or around the Delta. These schemes include a barrier at Chipps Island (Corps of Engineers); three alternative plans for conveying water across the Delta by a closed system of Delta channels (California Department of Water Resources); and a peripheral canal (Bureau of Reclamation).

38. The choice of a "best" plan is complicated by the imperfect understanding of the quantitative relationship between water quality and flow distribution (and magnitude) in the Delta area.

39. At the present time, Delta water users along the path of export water movement generally have water of adequate quality for most beneficial uses. However, particular problems arise seasonally

in two areas which may be indicative of future problems of consequence.

40. The western Delta has a seasonal increase in chlorides attributable to a reduction in river outflows and resulting incursion of sea water in the summer and fall. Future design hydrology under State and Bureau plans would lengthen the period of high chlorides to several years during periods of low rainfall and minimum outflow. These chloride increases affect municipal, industrial and agricultural uses.

41. In the eastern Delta, depletion of dissolved oxygen is a regular summer problem in the San Joaquin River around Stockton and fish kills have occurred in this area. In addition, total dissolved solids have occasionally been sufficiently high as a result of heavy irrigation re-use and low San Joaquin River flows to cause some adverse effects to crops in the Stockton-Tracy area and to require the application of additional water for leaching purposes.

42. Other more minor problems also occur as the result of seasonal waste discharges from the cities of Tracy and Lodi. These and other similar problems will be aggravated by increasing populations.

San Luis Drain

43. The San Luis unit of the Central Valley Project is a joint State - U.S. Bureau of Reclamation project comprising a system of canals, pumping stations and a large storage reservoir for distribution of water primarily for agricultural purposes. The San Luis service area includes over 600,000 irrigable acres in the western San Joaquin Valley, chiefly in Fresno County.

44. The Federal San Luis Act (PL 86-488) specifies that a drainage system must be provided for the San Luis service area.

45. A number of alternative drainage schemes have been proposed for the disposal of agricultural waste water outside the service area. The U.S. Bureau of Reclamation requested the Public Health Service to evaluate four schemes involving the conveyance of waste waters to specific locations, namely; the San Joaquin River near the Antioch Bridge; upper Suisun Bay at Chipps Island; Carquinez Strait at the lower end of Suisun Bay; and the Pacific Ocean in Monterey Canyon beyond the mouth of the Pajaro River. The four proposed waste discharge points are shown on Figure 18.

46. The physical conveyance schemes become progressively more costly as their discharge point is extended seaward. The Antioch location is essentially fresh water, the Chipps Island and Carquinez Strait locations are respectively more brackish and the Monterey Canyon strictly seawater.

47. The Antioch location is above a number of existing municipal and industrial water supply intakes. The only significant withdrawal uses below the Chipps Island and Carquinez Strait locations are industrial cooling water diversions. However, tidal action will result in some affect on withdrawal uses above these locations. All three locations receive considerable inplace usage, i.e. fishing, recreation and navigation.

48. The San Francisco Bay - Delta system will undergo considerable environmental changes in the future as a result of proposed water conservation projects. Project design conditions as envisioned by State and Bureau plans would allow only 1000-1500 sec-ft outflow

from the Delta for extended periods of time up to several years, depending on precipitation.

49. Mean evaporation losses in Suisun, San Pablo and North San Francisco Bays exceed the proposed minimum Bay inflow (1000 sec-ft) for a five month period each year. Land fill operations in the Bay are expected to reduce waste assimilative capacity by reducing the volume of the tidal prism and water surface area. Potential reclaimable land in the San Francisco Bay Estuary is indicated on Figure 20.

50. With little or no net outflow from the Bay through the Golden Gate over extended periods, the buildup of nutrients and other refractory materials will be accelerated.

51. Certain types of migratory fishes, mainly salmon and stripped bass, reside in the brackish waters of Suisun Bay for extended periods of time. The fishery resource of the San Francisco Bay system is highly valued.

52. At present, phytoplankton populations in Suisun Bay are very significant particularly in late spring and summer. Recent studies indicate that these populations have, at times, depleted essentially all of the available nitrogen in the water.

53. Discharge of agricultural wastes to Suisun Bay would increase nutrients and pesticide levels in the Bay. In addition, future municipal and industrial waste discharges will increase nutrient concentrations in spite of treatment since presently accepted treatment methods remove only a small portion of nitrogen and phosphorous compounds and convert the remainder to forms more readily available to aquatic life.

54. Waste-derived nutrients provide food for phytoplankton which in turn are food for other aquatic life including many nuisance organisms. Increased food supplies are expected to create increased algae populations with associated dissolved oxygen fluctuations, odors and other environmental and esthetic problems.

55. Pesticides tend to concentrate in certain algae, in fishes and in higher life forms with generally adverse affects. Low concentrations of many pesticides are lethal.

CONCLUSIONS

General

1. Ultimate development of California's water resources will result in practically complete control of most of the rivers in the Central Valley and will allow only a controlled minimum amount of surface water to be discharged from the Central Valley to San Francisco Bay and the ocean.

2. Future water use in the Central Valley in the year 2020 is estimated to be 19,000,000 acre feet per year, an increase of 8,000,000 acre-feet over present annual use (1960).

3. While the economy of the study areas has been predominantly agriculture, the generally favorable climate, central location, proximity to outdoor recreational opportunities and extensive areas of suitable lands has had and will continue to have a stimulating effect on industrial growth and urban development. Employment in the study areas is expected to grow at a rate higher than that of the State as a whole (which is higher than the national rate).

4. Population in the study areas has increased over 40 per cent in the past decade and projected urban growth to the year 2020 of major communities within the study area ranges from 4 to 9 times present populations.

River Basins

5. Table I-1 summarizes the estimated <u>treated</u> pollution loads which will be generated in the San Joaquin, Cosumnes and American River Basins in the period 1960-2020.

6. Table I-2 and I-3 present a summary of the estimated flows and storage requirements, respectively, necessary to provide adequate

water quality for most beneficial uses in the period 1960-2020. For comparative purposes, the quantities of water required annually for both gross and net regulation are presented. Gross regulation represents the total quantity of water required for quality control. Net regulation represents that quantity which must be derived from storage or other sources to supplement natural flow (including return flows). Net regulation has been calculated on the assumption that the existing hydrology (present impaired flow) would exist in the future and is based on a ten year low flow recurrence interval. While this assumption may not be valid in all cases it does provide an illustration of the probable range of quality control regulation required. Estimates of net regulation requirements can be modified as better projections of future hydrology become available.

7. Within the San Joaquin River Basin study area (excludes the Delta area and Stockton) some flow regulation is presently needed to supplement existing flows during the canning season. It is estimated that a total net regulation of 69,000 acre-feet are required within the basin and that about 50,000 acre feet of this amount is needed in the Tuolumne River in the vicinity of Modesto.

8. For purposes of determining quality control regulation, cannery wastes were assumed to be generated throughout a 120 day canning season. In actual practice approximately 50 per cent of the waste load is generated in 30 days with several days or weeks of peak loads. To provide adequate quality control, releases from storage would have to be varied to coincide with anticipated waste generation or else sufficient holding pond capacity provided to allow relatively uniform release of treated cannery wastes during the 120 day season.

TABLE I-1

ESTIMATED TREATED POLLUTION LOADS

(Pounds of total first-stage BOD (ultimate) per day at 20°C)

Basin	1960	1980	2000	2020
San Joaquin (1)	10,830	20,360	33,070	30,550
(2)	51,640	76,140	96,970	75,130
Cosumnes	740	1,910	4,260	4,790
American	10,000	13,500	15,500	11,200

(1) Daily load of organic wastes except during canning season.
(2) Daily load of organic wastes during canning season (120 days) assuming canning wastes are generated uniformly through the season.

The Delta

9. Because the Delta occupies a key position in California water resources development plans and directly or indirectly affects a majority of the State's citizens, its hydraulics, hydrology and water quality are of major concern.

10. The problems involved in maintaining a more intensive in-place water use (fishing and recreation) in the Delta in spite of large population increases and resulting municipal, industrial and agricultural waste loads will become increasingly difficult to solve.

11. Mathematical models augmented by collection of extensive field data for verification would appear to be most promising in furthering the understanding of the flow-quality relationships in the Delta. Solution of such a model through the uses of digital computation could provide a flexible tool with which to explore a wide variety of alternate schemes and operational schedules under various waste loading and

TABLE I - 2

ESTIMATED WATER QUALITY CONTROL FLOWS
(Cubic Feet per Second)

River River Mile	1960		1980		2000		2020	
	Base	Canning Season	Base	Canning Season	Base	Canning Season	Base	Canning Season
San Joaquin								
170	10	40	25	70	60	130	60	120
110	5	10	5	15	15	30	15	30
91+	15	100	35	135	50	160	50	120
80	100	630	200	850	320	970	290	670
76+ (Vernalis)	110	720	220	970	360	1070	330	750
Merced								
0	-	-	-	-	-	-	-	-
Tuolumne								
16	70	400	120	530	200	590	190	430
Stanislaus								
25	5	50	15	75	25	80	25	60
Cosumnes	5	5	15	15	40	40	50	50
American	140	140	190	190	210	210	150	150

TABLE I - 3

ESTIMATED ANNUAL WATER REQUIREMENTS FOR QUALITY CONTROL
(Acre Feet per Year)

River River Mile	1960 Regulation		1980 Regulation		2000 Regulation		2020 Regulation	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net
San Joaquin								
170	14,300	1,300	27,400	5,600	58,100	19,700	56,200	17,800
91+	30,600	0	48,200	1,000	62,600	3,200	51,900	0
80	200,000	69,000	298,000	121,000	378,000	144,000	300,000	78,200
76+ (Vernalis)	226,000	60,000	337,000	119,000	427,000	144,000	338,000	67,500
Merced								
0	-	0	-	0	-	0	-	0
Tuolumne								
16	129,000	49,500	184,000	81,000	238,000	95,000	191,000	55,000
Stanislaus								
25	14,600	0	24,500	0	32,100	0	24,300	0
Cosumnes	3,600	1,800	11,000	5,500	27,600	13,800	34,800	17,400
American	99,000	0	134,000	0	154,000	0	112,000	0

water use patterns. Limited application of this approach in this investigation has shown this to be a most logical and expedient method of analysis.

12. Increased stream flows in the San Joaquin River at Stockton would be beneficial to recreation and fishery interests as well as downstream withdrawal users. However, the problem of net upstream water movement during periods of intensive agricultural diversions and pumping at Tracy must be considered. Under present conditions, the flows necessary at Stockton to prevent this reversal will vary from zero during the non-irrigation season to well over 1000 cfs when irrigation is intensive. Physical works may be constructed to control this problem. However, no formal proposals exist at the present time.

13. Because of the effects of variable net upstream movements superimposed on tidal effects in the San Joaquin River at Stockton, more study will be required before a statement of flow requirements for quality control purposes can be made.

14. Increased outflow from the Delta would benefit the western Delta water users to some extent and could provide benefit from a pollution control standpoint in the future. However, a specific quantitative statement of flow needs related to water quality is not possible without a better understanding of the relationships between water quality, flow distribution and tidal effects. (These relationships are currently being studied to some extent by the California Department of Water Resources).

San Luis Drain

15. Considering only the four alternate waste discharge points

(Figure 18) and neglecting cost considerations, the logical order of site preference would be the Pacific Ocean first, Carquinez Strait second, Chipps Island third and Antioch last. This order is based on the respective increase in number of water uses (both inplace and withdrawal) and people likely to be affected by each discharge.

16. The San Luis service area represents less than 10 per cent of the ultimate area to be served by a master drainage system in the San Joaquin Valley. In addition to the San Luis service area, the proposed State Water Facilities and the Bureau's East Side Canal would provide irrigation, municipal, and industrial water to extensive areas in the Southern San Joaquin Valley. These areas will all require drainage facilities. The State's San Joaquin Valley master drainage system has been in the planning stages for a number of years and a final report is scheduled for January 1965.

17. It seems logical that any decision on the disposal of San Luis drainage will set a precedent for other plans for drainage from the entire San Joaquin Valley.

18. Since the ultimate decision on the disposal of San Joaquin Valley waste waters will have a direct or indirect effect on a major portion of the State's population and will cost millions, extra care should be taken in selecting the point of discharge to minimize detrimental environmental effects.

19. Bureau of Reclamation engineers point out that the volume of waste water from the San Luis project will be very slight in the next 10 to 20 years. Selection of an interim discharge point outside the San Luis Service area would involve considerable capital cost (e.g. over $30 million to the Antioch Bridge) making it difficult if not

impossible to change if significant damage is demonstrated after the drain is constructed and waste flows have increased. Therefore, any discharge point (interim or ultimate) should be selected only after careful evaluation and a determination that water quality and water uses in the long run will not be damaged significantly. It may be possible to effect a short term solution such as temporary evaporation ponds or discharge to a local water course along with sufficient dilution flow derived from surplus project waters until a master plan for San Joaquin Valley drainage can be agreed upon.

20. In order to properly evaluate proposed discharge points in the Delta or Bay region, it would be necessary to quantify changes in water quality and estuarine ecology for each discharge point under future conditions of minimum outflow and to measure the effects of these changes on water uses (both inplace and withdrawal). The data are not available for such an evaluation. Until such an evaluation can be made, the PHS does not have sufficient basis to conclude that any discharge point other than the Pacific Ocean is satisfactory.

21. Public Health Service investigations of San Luis waste disposal problem have been brief (about five months) and cover only a review of available data and literature. From this investigation, it has become apparent that the problem deserves considerably more study than this cursory examination.

Benefit Evaluation

22. Poor water quality conditions resulting from natural and man made pollution have caused detrimental effects to both withdrawal (municipal, industrial, agricultural) and inplace (fish, recreation) water uses in the Delta and tributary streams. Increased treatment of

municipal and industrial water supplies, reduction in crop yields, increased leaching water requirements, impairment of the fishery resource, and reduction in esthetic and physical enjoyment of water contact sports have resulted from water quality degradation in varying degrees of severity. An evaluation of the damages incurred (both tangible and intangible) as a result of present and probably future waste discharges with varying degrees of treatment would require much more time and money than were available for this study. However, a very rough approximation of benefits accruing from stream flow regulation, based upon the least cost alternative method, indicates that minimum benefits would probably range upward from $7.00 to $12.00 per acre foot of water storage required for stream flow regulation for quality control.

RECOMMENDATIONS

This report represents an evaluation and interpretation of existing data. As such, it does not reflect the best information that could be developed with additional suitable field data. The results, in most instances, are considered suitable for preliminary planning purposes. However, it is recommended that the information contained herein be refined and expanded before it is used in any final comprehensive plan for water resources development. Additional studies that appear essential for a satisfactory evaluation of certain water quality problems are as follows:

1. River characteristics. Develop additional data on the physical, chemical and biological characteristics of the major rivers receiving municipal, industrial and agricultural wastes. This should include such things as physical channel characteristics and time of flow studies; identification and quantification of biological life with particular reference to photosynthesis and respiration effects; and the quantification of nutrients and pesticides with particular reference to their effects on stream ecology. It is recommended that several carefully planned specific case studies be initiated to quantify and relate these effects in a manner which will allow reasonably accurate predictions of future conditions. The Modesto, Turlock and Riverbank areas appear to be prime locations for detailed study.

2. Stockton. Investigations should be initiated to determine the physical characteristics of the flow reversal problem in the San Joaquin River and its effects on water quality in the Stockton area. Studies should also be initiated to quantify the effects of waste discharges not only with regard to effects of organic wastes,

but also with respect to the effects of nutrients and pesticides on the ecology of the receiving waters. This area of the Delta presently receives most of the agricultural drainage from the San Joaquin River Basin as well as M & I wastes and may serve as a possible analogy to future conditions in the western Delta.

3. Delta. In view of the success achieved in the limited application of a mathematical model of the Delta and its great potential flexibility, it is recommended that these studies be continued to allow refinement of input data and digital computer techniques. It is also recommended that field studies be designed and carried out with the specific objective of thorough verification of the model outputs. It is further recommended that the solution of the diffusion problem through mathematical model techniques be thoroughly explored.

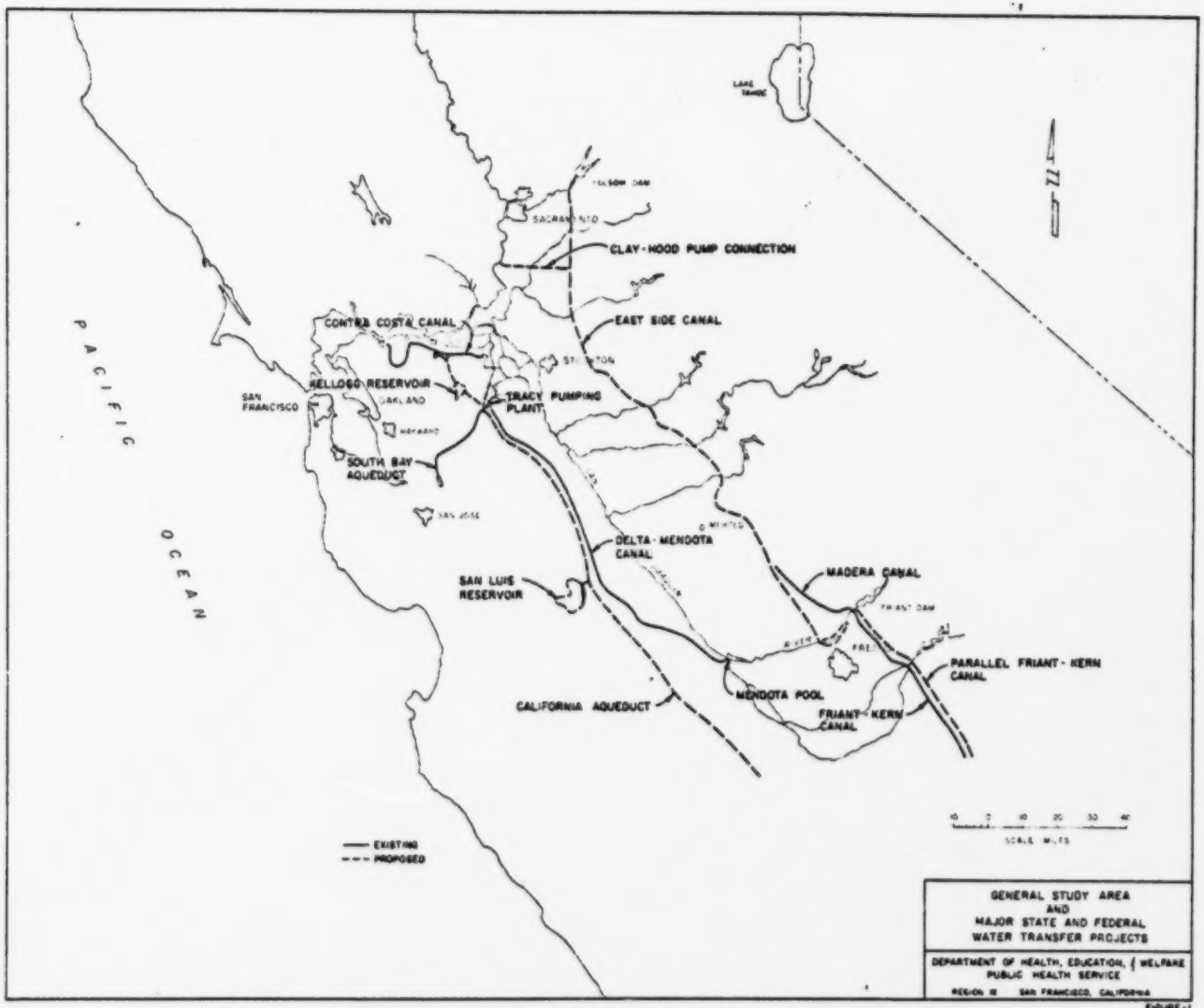
4. Western Delta, Suisun Bay and San Pablo Bay. Knowledge of the effects of continuous low outflows on future water quality in these areas is extremely limited. In view of proposed plans for disposal of agricultural drainage from the San Joaquin Valley along with increased pollution loads as a result of projected population expansion, every possible effort should be made to quantify the potential problems in order that solutions can be effected in advance. Preliminary investigations by the State indicate that the Corps of Engineers "Bay" model at Sausalito may reasonably duplicate prototype mixing conditions. All possible encouragement and support should be given to these studies. It is recommended that consideration be given to field tracer studies which could be designed to verify the hydraulic model results, particularly, under low flow conditions.

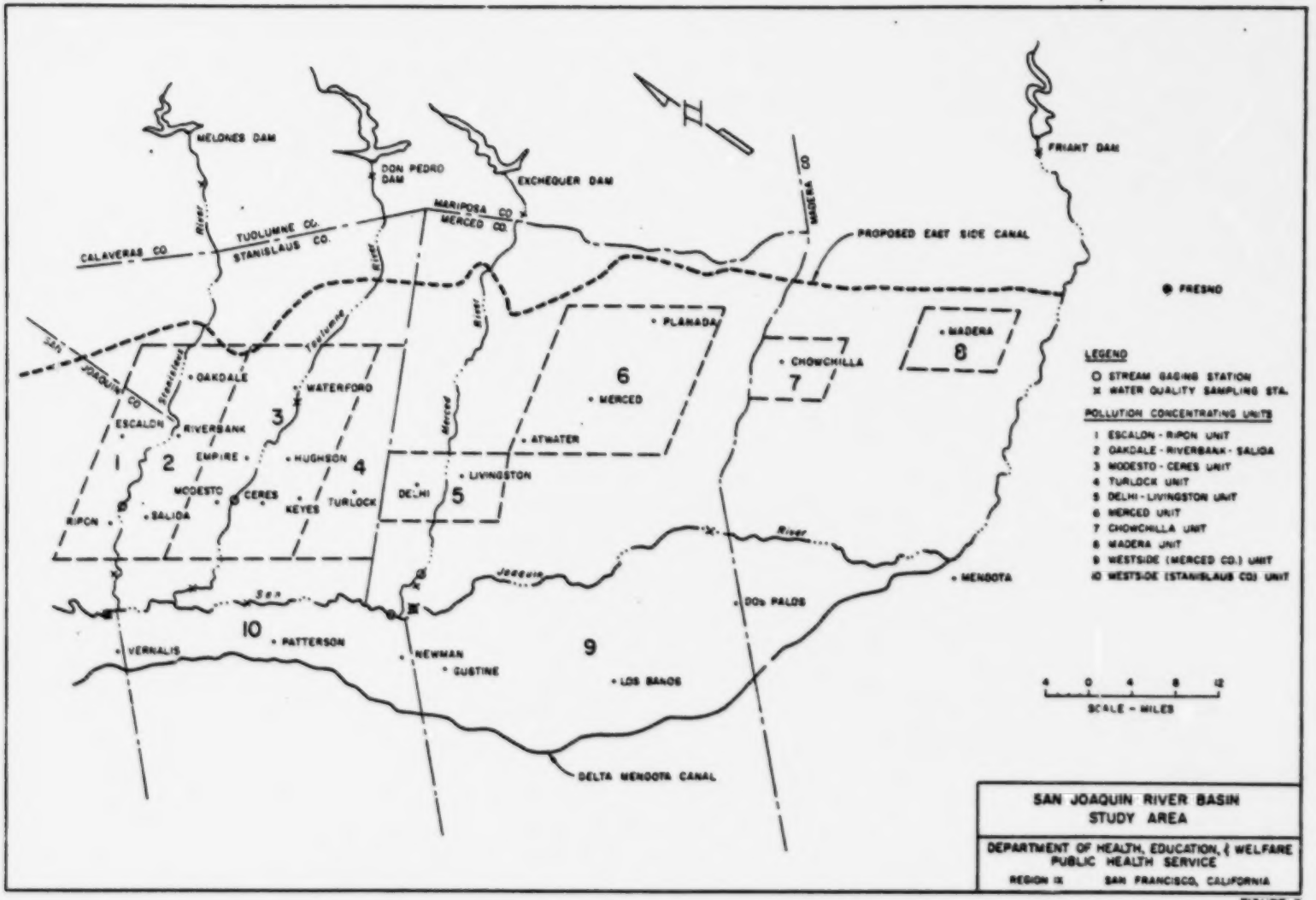
5. San Luis Drain. It is recommended that the final decision

regarding the disposal of San Luis wastes be delayed until it is reasonably certain that the adopted disposal scheme can be integrated into a master plan for the entire San Joaquin Valley. Other alternative disposal schemes should be considered including the reclamation of waste waters. An evaluation of the potential municipal and industrial waste sources must be made in addition to agricultural sources. The final selection of a disposal site should be made in light of the potential discharge from the entire San Joaquin Valley master drainage system and the results from studies suggested in Recommendations 3 and 4 above. This is particularly important for disposal sites in the San Francisco Bay region since under future project conditions net advective flows will be a minimum and potential for pollutant build-up a maximum.

6. Economic evaluation. The costs of the various State and Federal alternative project proposals are high. The potential effects of these projects on population growth, economic activity, generated waste loads and water quality can be very significant. Efforts should be continued to develop (1) a resources inventory and analysis of economic activity in the Central Valley, its linkage with related economic activity and markets outside the region and analysis of the relationship between economic activity and availability and quality of natural resources; (2) projections of future economic activity and problems in the Central Valley based upon specific assumptions concerning National, State and Regional growth and the availability and quality of resources within and outside the Central Valley with such sub-division of the Central Valley which appear reasonable; and (3) the development of an analytical device for determining

alternative project supply effects that permits rapid modification of the economic estimates and involves quantification and pricing of stream pollution effects.

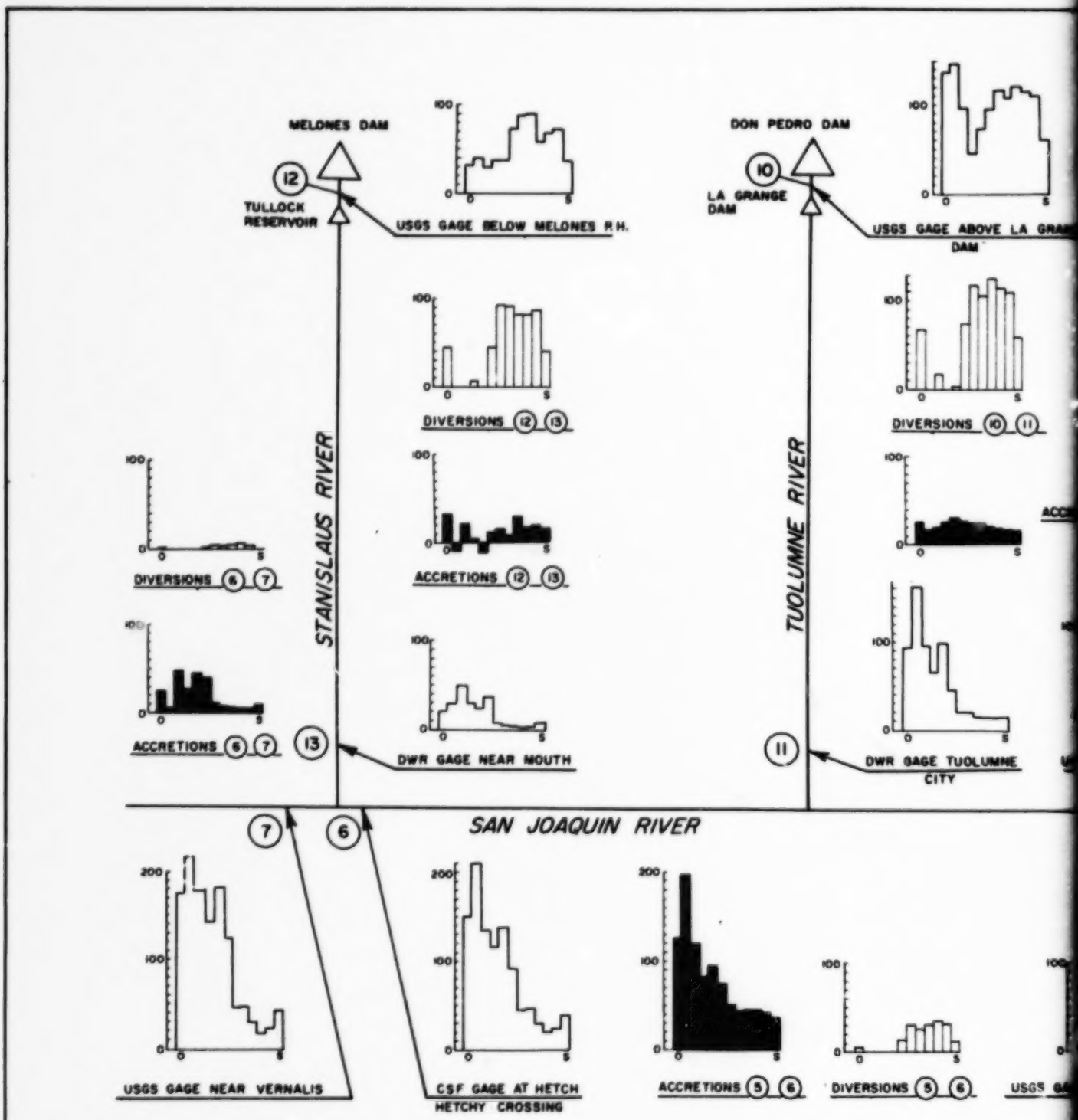

PACIFIC
OCEAN
SACRAMENTO
CLAY-HOOD PUMP CONNECTION
CONTRA COSTA CANAL
EAST SIDE CANAL
HELLOGG RESERVOIR
SAN FRANCISCO
OAKLAND
TRACY PUMPING PLANT
SOUTH BAY AQUEDUCT
DELTA-MENDOTA CANAL
SAN LUIS RESERVOIR
MADERA CANAL
PARALLEL FRIANT-KERN CANAL
MENDOTA POOL
CALIFORNIA AQUEDUCT
FRIANT-KERN CANAL
EXISTING
PROPOSED
GENERAL STUDY AREA
AND
MAJOR STATE AND FEDERAL
WATER TRANSFER PROJECTS
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA
FIGURE-1



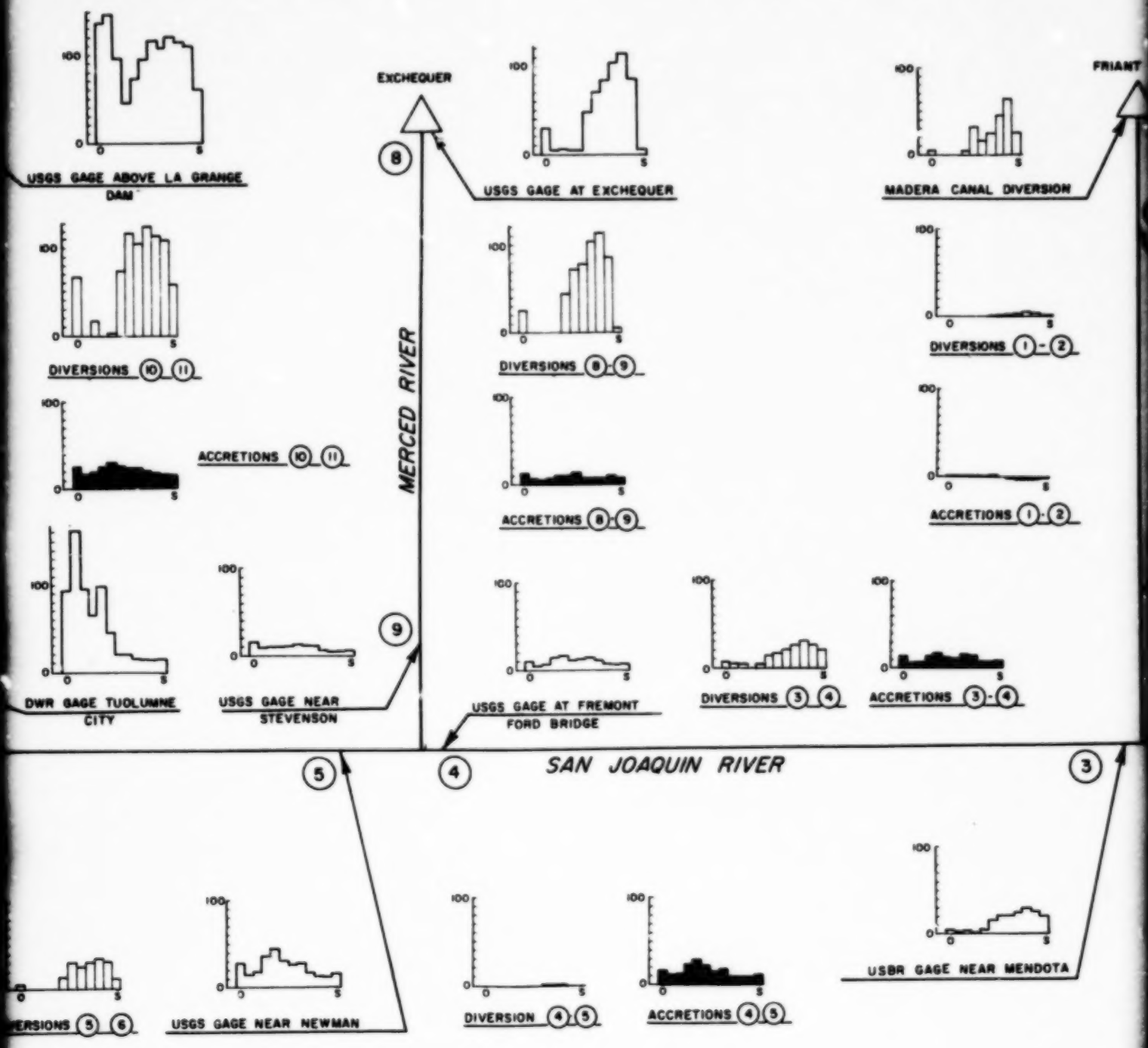
SAN JOAQUIN RIVER BASIN
STUDY AREA

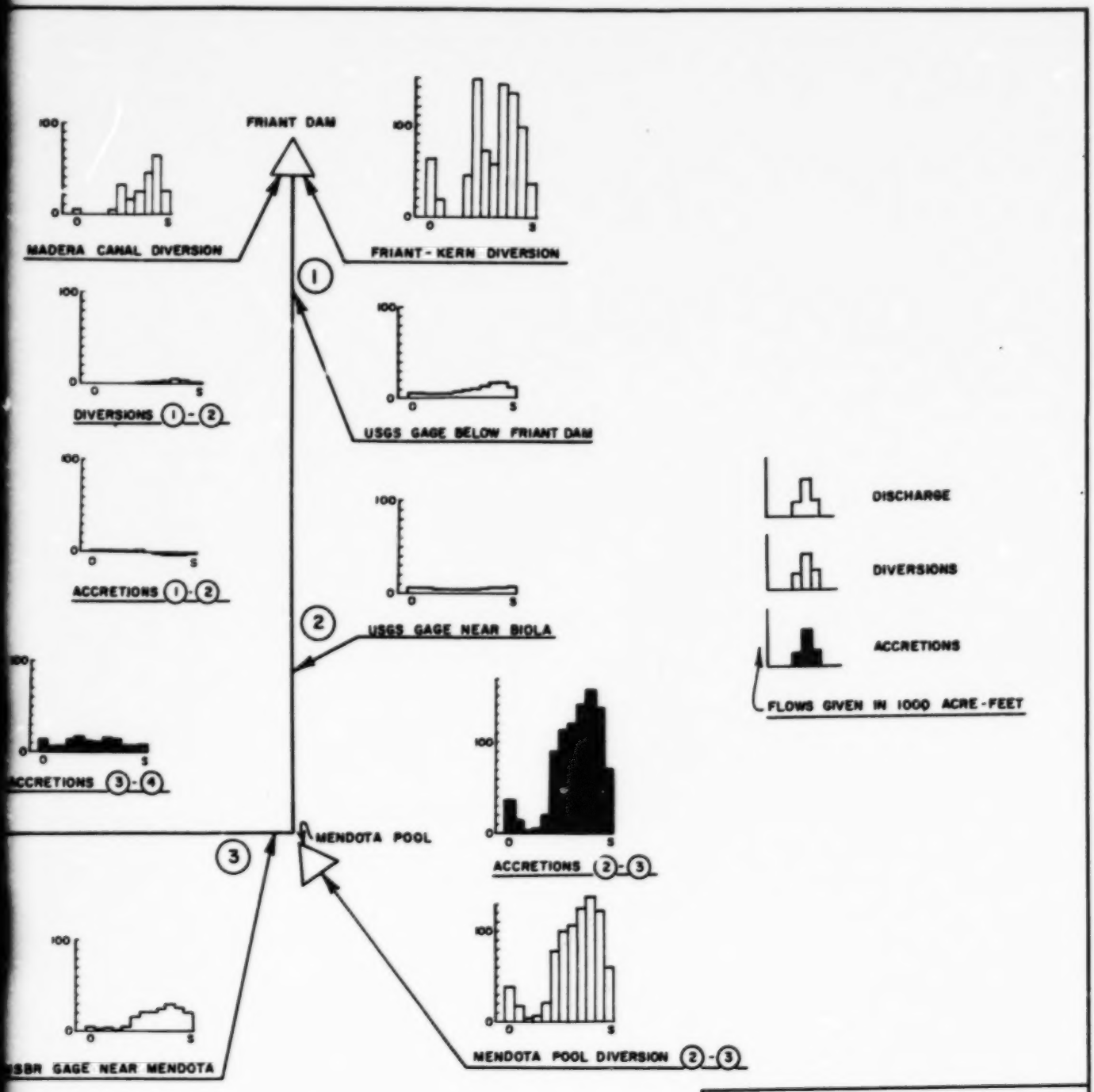
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE-3


MELONES DAM
12
TULLOCK RESERVOIR
USGS GAGE BELOW MELONES R.H.
DON PEDRO DAM
10
LA GRANGE DAM
USGS GAGE ABOVE LA GRAN DAM
DIVERSIONS 12 13
DIVERSIONS 10 11
STANISLAUS RIVER
TUOLUMNE RIVER
DIVERSIONS 6 7
ACCRETIONS 12 13
ACCRETIONS 6 7
13
DWR GAGE NEAR MOUTH
11
DWR GAGE TUOLUMNE CITY
SAN JOAQUIN RIVER
7
6
USGS GAGE NEAR VERNALIS
CSF GAGE AT HETCH HETCHY CROSSING
ACCRETIONS 5 6
DIVERSIONS 5 6

GPO 967497

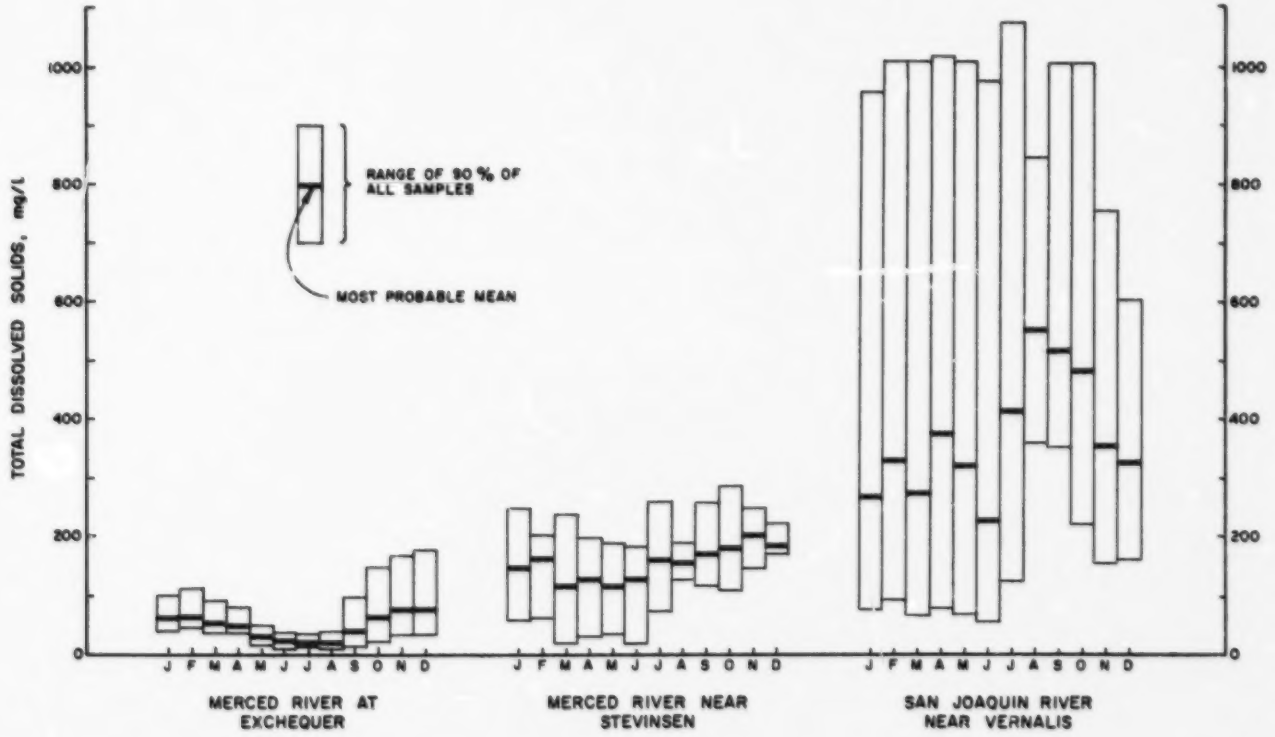

EXCHEQUER
FRIANT
MERCED RIVER
SAN JOAQUIN RIVER
8
9
5
4
3
USGS GAGE ABOVE LA GRANGE DAM
USGS GAGE AT EXCHEQUER
MADERA CANAL DIVERSION
DIVERSIONS (10) (11)
DIVERSIONS (8) - (9)
DIVERSIONS (1) - (2)
ACCRETIONS (10) (11)
ACCRETIONS (8) - (9)
ACCRETIONS (1) - (2)
DWR GAGE TUOLUMNE CITY
USGS GAGE NEAR STEVENSON
USGS GAGE AT FREMONT FORD BRIDGE
DIVERSIONS (3) (4)
ACCRETIONS (3) - (4)
USGS GAGE NEAR NEWMAN
DIVERSION (4) (5)
ACCRETIONS (4) (5)
USBR GAGE NEAR MENDOTA



HYDROLOGIC SYSTEMS CHART
OCTOBER 1958 THROUGH SEPTEMBER 1959

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIF.

FIGURE - 10



SEASONAL PATTERN OF TOTAL DISSOLVED SOLIDS FOR SELECTED STATIONS

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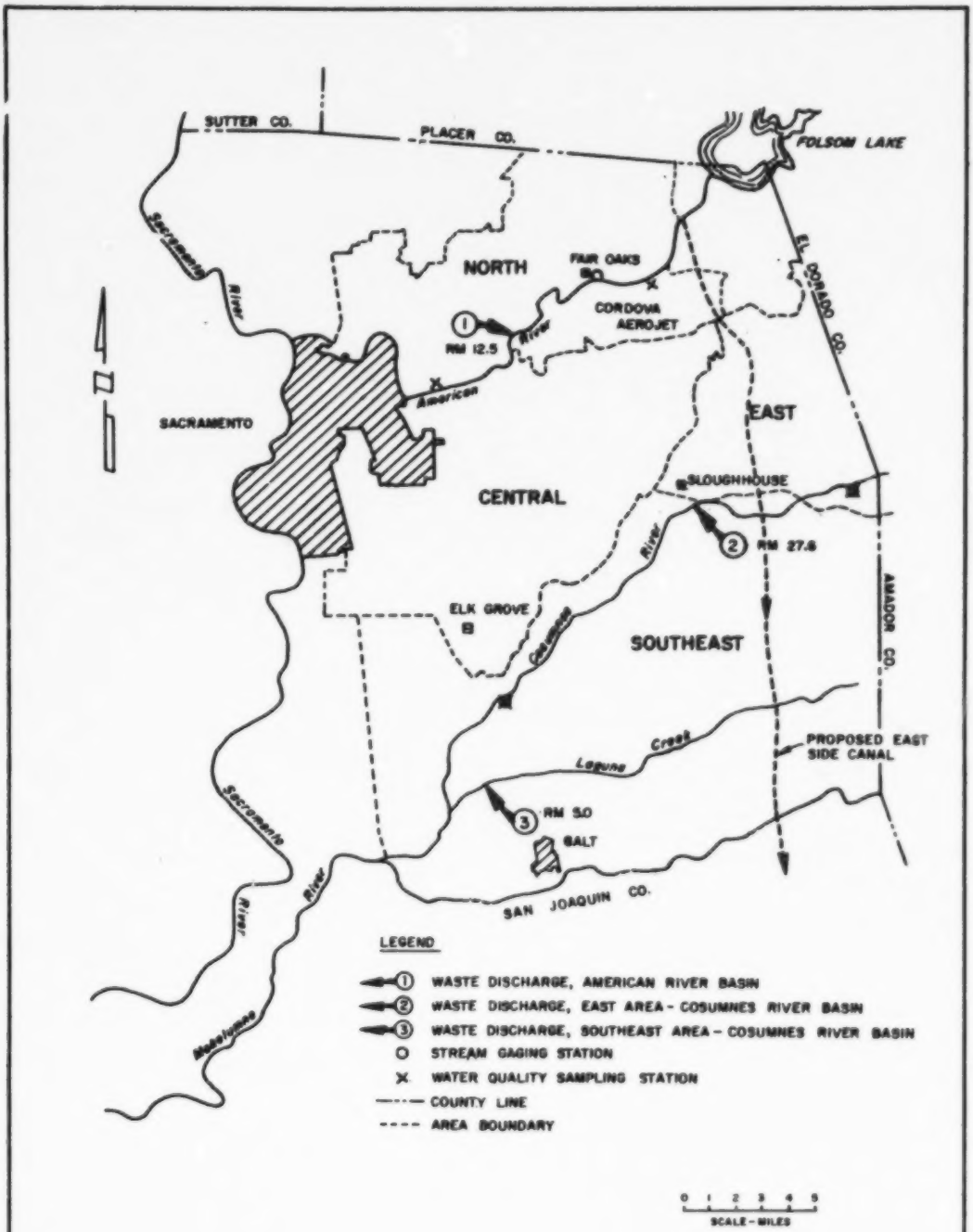
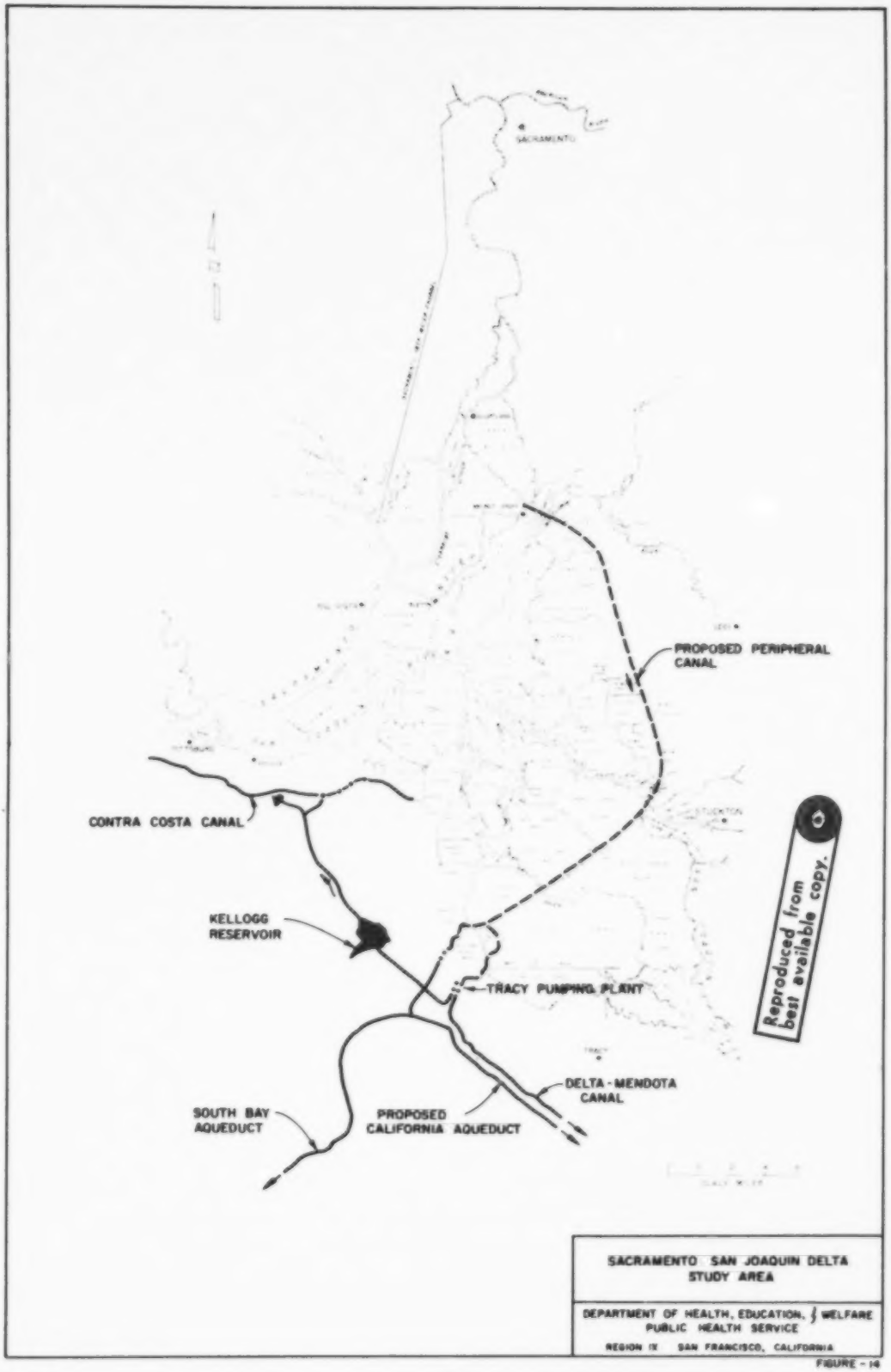
FIGURE-11



AMERICAN - COSUMNES RIVER BASIN
STUDY AREA

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE - 13



SACRAMENTO SAN JOAQUIN DELTA STUDY AREA

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE - 14

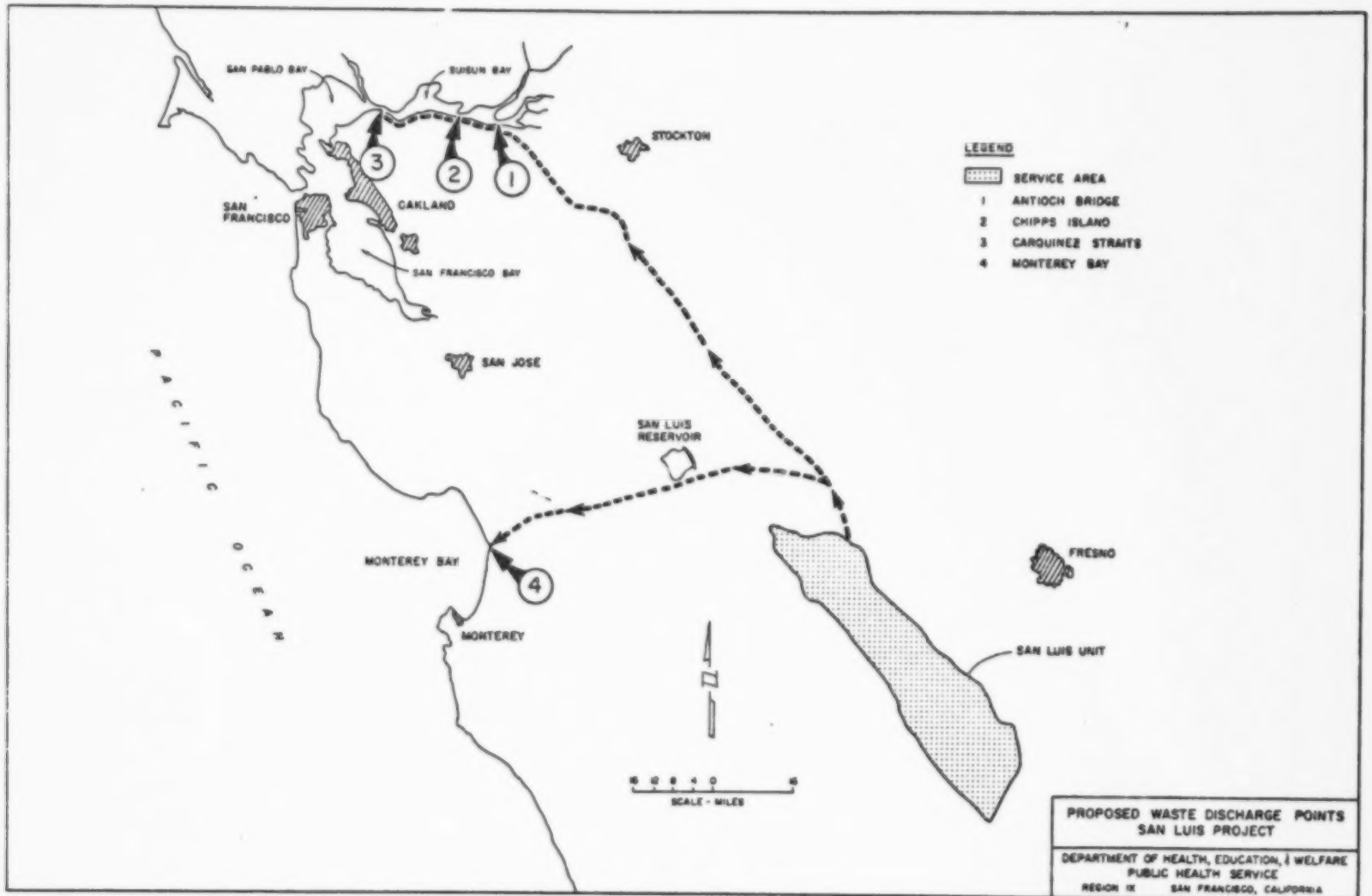

SAN PABLO BAY
SUISUN BAY
STOCKTON
OAKLAND
SAN FRANCISCO
SAN FRANCISCO BAY
SAN JOSE
SAN LUIS RESERVOIR
MONTEREY BAY
MONTEREY
FRESNO
SAN LUIS UNIT
PACIFIC OCEAN
LEGEND
SERVICE AREA
1 ANTIOCH BRIDGE
2 CHIPPS ISLAND
3 CARQUINEZ STRAITS
4 MONTEREY BAY
SCALE - MILES
PROPOSED WASTE DISCHARGE POINTS
SAN LUIS PROJECT
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE-18

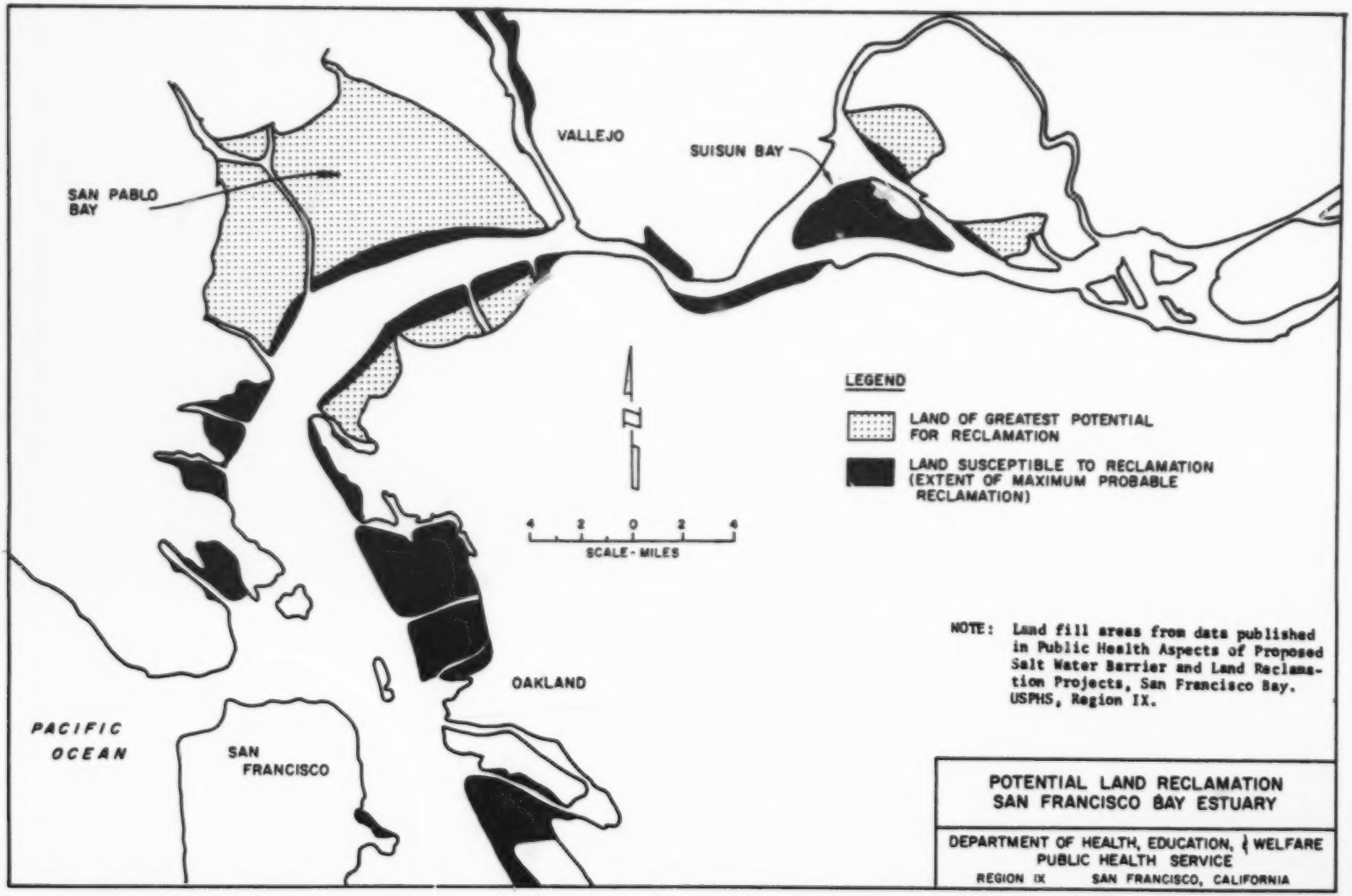

VALLEJO
SUISUN BAY
SAN PABLO BAY
LEGEND
LAND OF GREATEST POTENTIAL FOR RECLAMATION
LAND SUSCEPTIBLE TO RECLAMATION (EXTENT OF MAXIMUM PROBABLE RECLAMATION)
4 2 0 2 4
SCALE - MILES
NOTE: Land fill areas from data published in Public Health Aspects of Proposed Salt Water Barrier and Land Reclamation Projects, San Francisco Bay. USPHS, Region IX.
OAKLAND
PACIFIC OCEAN
SAN FRANCISCO
POTENTIAL LAND RECLAMATION
SAN FRANCISCO BAY ESTUARY
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE-20